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WEBER'S ARCHIVES

CONTRIBUTION TO KNOWLEDGE IN ANIMAL EVOLUTION—II

MUTATION IN MOSQUITOES

DISCUSSION AND COMMUNICATIONS

FROM THE RESEARCH LABORATORY OF

SAMUEL ELLSWORTH WEBER

VETERINARIAN

Compliments of the Author.

LANCASTER, PA.

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MUTATION* IN MOSQUITOES.

FROM THE RESEARCH LABORATORY OF

SAMUEL ELLSWORTH WEBER, *Veterinarian,*

LANCASTER, PA.

Among all questions, theoretical or practical—philosophical, scientific, ethical and those of every day life—the problem as to the origin of species I may say stands second only to that of man's conception of himself and his destiny.

It is not the purpose of this paper to discuss the philosophy of the mutation theory or the data upon which it rests, but simply to record as briefly as possible, in trite terms, a few facts of some important observations—omitting detail and technique—in that process of evolution as furnished by the *Culicidæ*.

The question of the origin of species is the origin of specific characteristics or differential marks. According to one theory they arise gradually through accumulation of the order of fluctuations. According to the other they arise suddenly and completely as mutations. By this method new species have been seen to arise in the succession of generations in plants, where the process was brought under direct observation.

The study of the *Culicidæ* in this problem is pregnant with great interest and affords the philosophical student one of the most important fields for research in animal life. Convinced of certain apparently strange phenomena in the life history of mosquitoes, while studying their connection with the transmission of disease, as early as a quarter of a century ago, and impelled

* *Mutation*—(Lat. *mutatio,* from *mutare,* to change).

1. The act or process of changing.

2. Change: alternation, either in form or qualities.

This is Webster's definition of the term, and is made use of in this connection with the same meaning as de Vries attached to it for the same process of evolution in plant life.

with the desire, after years of delay, to know the truth with reference to the correlation of certain manifestations not understood at that time, these investigations were again taken up three years ago and the process followed out.

Not infrequently when studying a generation, I was puzzled in finding one, two, or more specimens of a different species, which were generally accounted for as being present accidentally in some way or other, even after a careful daily watch against other depositions. The occurrence of single specimens, however, in default of finding no similar forms in any of the other vessels containing generations of depositions of the same genus, enshrouded a still further mystery, since the specimens were of the *Culex pipiens* group, which undoubtedly deposit no eggs other than the well known raft or boat-shaped mass. Such were some of the conditions attending ordinary rain-barrel investigations. Now, after a careful screening of the barrels, and the most rigid precaution against mixture of species in the handling of material, what follows? The result, in a word, was the same.

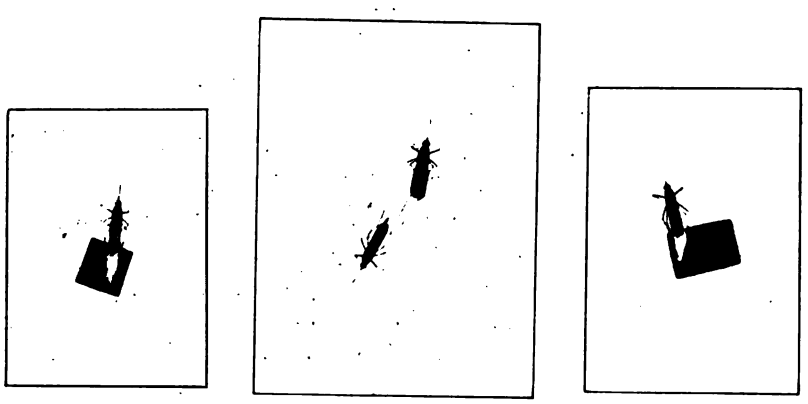

FIG. 1. *Culex pipiens* Linnæus, showing position taken in the act of ovadeposition. Natural size, photographed from life by S. E. Weber.

Under the circumstances stated there was still some room for doubt, but there is a further series of conditions which indicate the facts more clearly, and which removed all doubt from my mind as to the validity of the unusual presence of individuals of a different species. These conditions consisted in the rearing of

egg-masses under the same precautions at different stages in the season. In the fall, for example, especially in the latter part of October, when temperature conditions favorable to deposition occur only periodically, accurate observation is made easy. The species, for the purpose in question, is the latest mosquito in the season to deposit eggs, in the locality where these observations were made. These late depositions, as a rule, are limited in number and have been seen in a warm part of the day, when, within a few hours it was again too cold for any deposits to be expected.

The fact of knowing every egg deposition that was made on a certain date, as October 25, and knowing moreover that by reason of cold weather no other deposits were made until November 1, and no more thereafter, should obviate any suspicion as to accidental or unknown deposit of a given mass or number of egg masses. Not only were the advantages of precautions favored by natural conditions made use of, but at all times during the season the food and water of all vessels wherein larvæ were bred was sterilized and the vessel screened. It was from the study of egg masses and their production under such precautions that the process of mutation in mosquitoes was revealed. In fifteen thousand eggs under observation, deposited by *Culex pipiens* Linnæus mosquitoes, in the season of 1904 and 1905, thirty-seven typical *Culex restuans* Theobald were produced.

After learning the unquestionable fact that two or more separate and distinct species may be produced from the same batch of eggs, the pleasure afforded me when the work of Professor de Vries fell under my eye can hardly be realized, for what he observed in vegetable life, was known to me in animal life. With reference to his work with the marked mutability of the American Evening Primrose, *Œnothera lamarckiana,* I can state, that it finds a parallel in my observations of the conditions of instability in the domestic mosquito, *Culex pipiens.*

A biologist in personal conversation among other remarks, said, "If you can prove that they (*the mutants*) are new species." "Ah! Professor, that is just what I wish to avoid, for that reason the old established Linnæan species of mosquito *Culex pipiens* Linnæus was chosen for these observations." This species, with

two others, *Culex restuans* Theobald, and *Culex salinarius* Coquillett, which are of the same genus, constitute the three forms for the present consideration. A remarkable fact is that *C. restuans* has figured as a mutant from both *C. pipiens* and *C. salinarius*. In my manuscript notes it is described as appearing as a mutant from *Culex pipiens* before it was described by Theobald. My observation leads me to believe that *C. restuans* may not be a well established species; for in 79,071 egg masses of *C. pipiens* collected in a manure pit at Lancaster, Pa., in the summer of 1906, only one mass of *C. restuans* was found. This will be treated later in this article. During the same period there were fifty-five depositions of *C. salinarius* in the same place.

To know whether or not a certain larva or adult specimen of *C. restuans* was produced from the egg deposited by a *C. restuans* female, it is necessary to see the deposition, for it seems to appear more frequently as a mutant from *C. pipiens* than by a progenitor of its own species. It must not be assumed, as suggested by the dialogue above, that the first observation of a new form is its first appearance, for observations teach me that—in general—the process of mutation may be regarded as a characteristic which manifests itself at different periods in the history of animal life. But this may not be found applicable in insect life, inasmuch as I have seen the phenomena active in the *Culicidæ*—as well as other insects—for a period of three years in the same locality. Whether the conditions of instability extend over periods of a greater or lesser number of years, or whether they always exist in this class of insects is unanswerable. It is, however, reasonable to believe that such phenomena always have existed but may be more or less active at different periods.

A worker in evolution remarked, "Your mutants may be hybrids," Well: let that be the case with some of the forms I have seen which seemed to have been mutants; but what about the three separate and distinct species just named, belonging to the Linnæan group? Can you cast aside *Culex pipiens* as untrustworthy, with the mere statement that it is only a variety, or a hybrid of some other form, and that the new species; or as in this instance an old established species, occurring in mutations, is to be regarded as a reversion to an ancestral type? No, cer-

tainly not. This is approaching Mendel's law, which is not applicable in this connection. If *Culex pipiens* were produced by cross-fertilization, then the repeated appearance of this species from egg-masses of other species would in every instance result from hybridization. If it was originally produced by such a process then it has become fixed and departs entirely from the Mendelian procedure, since it is the most common species of mosquito. In Mendel's law the proportions are supposed to be equal, so that in the appearance of one or more aberrant forms in a mass of three or four hundred eggs that method cannot be considered in the question.

The characteristics, while clearly to be differentiated in the adults of the species in question, are still more clearly brought out in their larval life, and it may be regarded as particularly fortunate that it was possible to carry out these observations on one of the old accepted species of Linnæus himself. And furthermore (as will be shown presently), that it was possible also, to place this species in direct line of succession by mutation with two other unquestionable forms of the same genus; otherwise the objection might be urged that the characters exhibited by the mutants were not of specific value. But, since the one species has been known for over a century, and the others have been well known, and are recognized as distinct by systematists the objection from that source is silenced.

The physiological chemistry of the egg, fertilization, temperature, environments; a detailed zoölogical description of the species in question, as well as many varieties, etc.—in other words, the description of the elements of the species—are some of the most important features, which, to more fully respond to the demands of the subject, should be treated in detail. Nor will space allow an attempt to describe in any detail a laborious task in the unraveling of a wonderfully unique process in the life history of mosquitoes. All this, and much more, which can not be compressed within the limits of this communication, must be passed by. Just enough illustrative single examples from many, will be presented to portray the cardinal points of the subject in question. I will therefore invite your attention to a few examples of generations from my notes, which are simple

facts as I have found them to exist in nature. All observations with exceptions which will be noted made for the purpose of this work have been from the egg masses of known progenitors.

THE EGG-MASS.*

Before proceeding it will be necessary to look upon the egg-mass of the *pipiens* group of mosquitoes as *a polygenetic factor,*

FIG. 2. *Culex pipiens* Linnæus† in the act of ovadeposition. The eggs from this progenitor gave rise to mutants of *Culex restuans* Theobald.

* An outline of this investigation on the mutation process of evolution will be found under the title: "*Polygenese bei den Eiern der Stechmücken* (*Culicidæ*)." "Natur und Haus," Jahrg. XV., Heft 15, I. Mai, 1907, S. 236–237.

† Unfortunately this specimen happened to be considerably rubbed on the dorsum of the thorax, and for that reason it was not possible to produce a photograph showing the typical lines formed by the scales on that area in a fully clothed specimen.

In this work I have made it a rule to try to secure the photographs as well as the descriptions of the mosquito depositing the eggs for these observations. In so doing, descriptions and photographs have accumulated While it would be interesting and important to give an account of each progenitor, I regret to say that this work is too extensive to be treated in a single article. To say that the mosquito, represented by Fig. 2, which produced the eggs of the generation in question was a *Culex pipiens* Linnæus must be sufficient.

—endowed with the power of producing more than one species. Such a condition is obvious to the process in question, for without the possibility of such a capacity there could be no mutation. We are now also naturally confronted with the question of fertilization of the egg-mass, which is a most difficult feature in this line of work. But this does not seem to be of paramount importance, since this study deals with a law, which, by way of general proposition expresses the regular method, and which, for the want of a better term, we designate at present as the law of mutation.

Polygenesis or the production of more than one species from the same egg-mass will doubtless prove a proposition difficult to bring to the minds of even the most careful scientists. Appreciating that it is contrary to ancient or modern belief as to the laws of nature, the statement is nevertheless made, and will be supported by convincing facts. The several features of importance in connection with these researches are not hasty conclusions or the result of a few years of study but even extend beyond a quarter of a century amid the pleasures, trials, and adversities in a difficult but guarded labor.

After familiarizing myself with the strange phenomena and unraveling the question in connection with it—the question of polyembryony—in some parasitic hymenopterous insects of the family *Chalcididæ* I set about looking for other phenomena which would further explain Polygenesis, or the production of different species from the same egg, which I thought should be correlated with the process of budding from the same egg as I found it in Polyembryony. In this, fortune has been propitious to me.

The following phylogeny will help to convey my meaning:

POLYGENESIS	*Polyembryony.* The production of chains of individuals from one egg. (embryonic budding).	*Examples.* *CHALCIDIDÆ.*
	Mutation. The production of more than one *species* or *genera* from the same egg deposition.	*CULICIDÆ.* *PSOCIDÆ.*

The second phenomenon in Polygenesis is a step which bestrides a colossal question, and in the extraordinary process is found the widest bearing upon profound biological problems.

A zoölogist asked the question—" What was the fertilization of the egg-mass which gave rise to different species? " Upon my reply that " I do not know," he was ready to drop the discussion. The burden of proof in this work, will be, to show the independence of the important question of fertilization regarding the mutation process in insect life. To the biologist, who has studied the varied vital powers and susceptibilities of the reproductive cell, and halted at the question of fertilization, I may say, that these observations in the phenomena of changes proceed by that point, disregarding it as the most vital factor. It is one of many influences which may be operative in these changes. Fertilization seems to be a law of preservation rather than that of organization of species. Unless it can be shown that the intra, as well as the extra-procedure in these phenomena regarding the life history of mosquitoes are principally governed by fertilization, this influence cannot be accepted as the principal cause. This may only be proved by further study of the law which embraces both types of mutation—with, or without integrations.

The type of mutation referred to in the phenomena in question, notably the reversion of life stages, of different species which had issued from one egg-mass to the progenitor which deposited the eggs, and the coming out from one and the same egg-mass of different species by a certain internal force of nature, is not the type which constitutes a mutant in the sense in which the term is used by de Vries. The latter is based on unit characters which will not fractionize with other characteristics. Such discontinuous variants or mutants may be seen to issue from egg-masses while the other method is operative.

Since the combination of different larval species and the folding into one adult species is a fact, the unfolding must be looked for in the stream which flows from the internal state, which must be through the egg, for we have no bud-sports or shoots in animal life. (*I. e.*, not like in plants; of course we have the embryonal budding in insects as mentioned under polyembryony.)

Our only course is to accept the egg-mass as the only medium through which sports—or species assuming a different character from the parent—are suddenly produced. *Hence the polygenetic power of the egg-mass in mosquitoes.*

If the egg-mass which produces three distinct species in larval life would always produce adults as represented by each species of larvæ, the biologist might break the work at this point, by

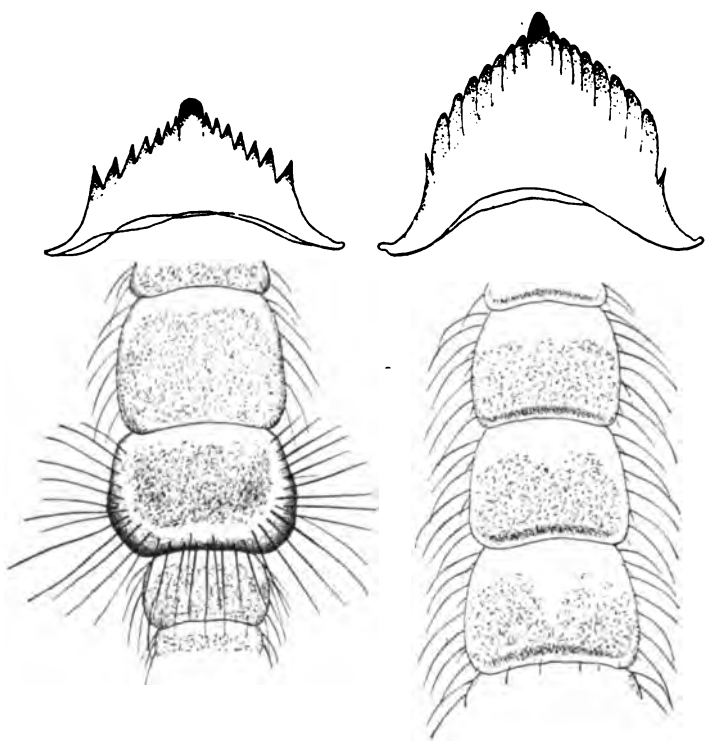

FIG. 3. Labial plate of the larva, and extraordinary development of abdomen in the adult of an aberrant male specimen in a generation herein described on the left. The same parts in their normal development of *Culex pipiens* Linn. on the right.

maintaining that the female was fertilized by the male of the three different species represented, or that they may have been hybridized species, etc. This brings us to the principal feature in this work, and from repeated observations I have been forced to the conclusion: that the reversion of different larval species

which have been produced from one and the same egg-mass, to individuals of one species in the adult (the same as the original progenitor of the egg-mass), *is but a part of a certain internal law of form.* This is the scheme of nature with which this work is concerned; and, therefore, fertilization plays no principal part in this observation. That fertilization is concerned more with the law of preservation of species than with the organization of species (in the process in question) will be supported by further facts on mutation in the *Psocidæ*, where the phenomena of changes found in the *Culicidæ* do not enter into the question. If fertilization even should be proved to influence the guidance of the different species either in the coming out to the adults as represented by the larvæ, or in the reverting to one adult form, the same as the progenitor of the egg-mass, I am still able to say, that, after all such a difficult task should have been performed, it would not be sufficient to upset my observations *on the inherent powers of the reproductive cell.* If nature can take back these forms, she can reproduce them; herein lies the principle. If two can close to one, then one can open to two. In other words, if two or more species are brought out of nature through one egg-mass, then the reverse should be expected; *i. e.*, the reversion of two or more larval species, to one species in the adult form. These are phenomena which await demonstration by examples which will follow.

With regard to color, the mutation process in the evolution thereof is similar to that found in structure. We may see a number of different colors in the same species of larvæ from the same mass of eggs producing adults of one and the same description in color. Here we have exemplified what may be termed the inward process of color mutation. Examples of the outward process are also numerous among the insects in question. In the latter direction we find striking examples in variety of color in the same species, in the higher animals, as the white crow and the white barn swallow, and in our grey squirrels we find exhibited in many localities a striking number of black individuals.

Owing to the wonderful complexity of the protoplasmic cell

in organization and function, containing all the varied vital activities of animal life, and recognized as a primary body in which is lodged the principles of the whole in higher organisms, the cell has of late years become the object of numerous researches on the part of biologists. Several of these have been relative to the powers and susceptibilities. In the study of such an important question it is perhaps safe to say that nothing could be advanced which could throw a more interesting ray of light upon the powers and susceptibilities of the reproductive cell, than the discovery of the polygenetic power vested in the egg-mass of mosquitoes.

The theoretical importance of the results of these observations regarding the capacities of the egg can hardly be overestimated, and it would be difficult for contemporaries to eliminate the interpretations which might be assigned to the facts. It is self-evident that in a mutation some changes or qualities are transmitted from cell to cell. Just what such changes may be, or in what manner the separate qualities are represented in the chromosomes in which the mutative changes must take place, is the interesting problem for the cytologist to explain. It may be said, however, that in the division of cells qualities must be thrown into a latent condition, or perhaps totally lost, while others may be acquired, through what actual operation is unknown.

CULEX RESTUANS THEOBALD AS MUTANTS FROM CULEX PIPIENS LINNÆUS.

As a first example of *Culex pipiens* in a state of mutation let us select a mass containing 352 large size eggs (Fig. 2), deposited September 29, 1905. This generation produced 43 medium sized mosquitoes, three of which were *C. restuans* females, and two were a variation from *C. restuans* females, and two others also females, were of the same beautiful deep cherry-reddish-brown tint with all the other parts as to color and size like the *C. restuans* and variation, but did not have the scaled spots on the dorsum.

When the elements of the species in question are carefully studied, what I have here called a variation may be found the

true and fully developed species *Culex restuans* Theo. The description of this latter species places two spots on the dorsum of the thorax. In a personal letter from Theobald he distinctly says " two round pale scaled spots on the mesothorax." These spots are the principal marks of contrast between *Culex pipiens* and *Culex restuans* in adult life. When viewed from above the two specimens which varied from the regular form of *C. restuans* presented four round pale scaled spots, two on the mesothorax, and two further apart on the antero-lateral part of the dorsum of the thorax, in a line with the prothoracic emi-

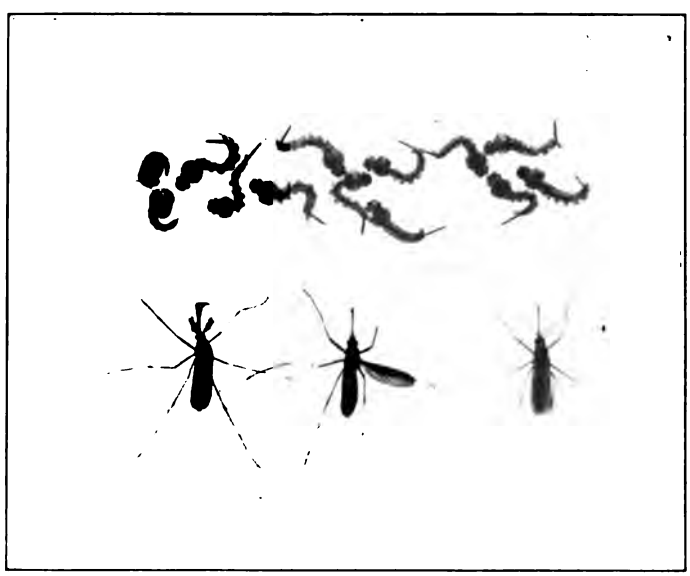

FIG. 4. *Culex pipiens* and *Culex salinarius* larvæ and pupæ from *Culex salinarius* eggs, photographed from life, enlarged seven eighths. The contrast between the two species may be noted in the size of the head and air-tube. The adult specimens are one male and two female *Culex salinarius.*

nence, which in these specimens is also clothed with a cluster of scales forming a small spot. The usual scaled spots on the side of the thorax were well marked and of a faint yellowish-white color. Viewed from the side, the two spots, one on the mesothorax, and the one on the prothorax were plainly seen. With reference to the lower spots I may say that in *C. pipiens* at this very point of the dorsum of the thorax—generations

are found which have on this same area a small group of from three to five scales, which in some individuals are sufficiently developed to form more or less of a spot noticeable to the unaided eye. These rudiments exist, and four spots instead of two may be a more fully developed individual of *C. restuans.*

In the four-spotted variety of *Culex restuans* the female is of the following description: Proboscis has a dark apical half with the point rufose. A marked difference is the prominent yellowish band formed by the closely appressed scales on the occiput just back of the eyes, which at the juncture between the eyes forms a prominent triangular spot. The occiput is clothed with numerous erect forked scales, all of a deep reddish-brown color. Antennæ of the same dark color with pale articulations. Dorsum of thorax contains no scales other than the four spots, with exception of caudal third. Halteres pale brown. Venter of abdomen thickly clothed with pale scales, mottled with a few rufose ones on sixth and seventh joints; and in the other individual a dark median line of black scales was found clothed with yellowish setæ. Knee joints white: marked yellowish white bands on distal ends of tibiæ; light banding of the tarsi.

A male specimen (length 7 mm.) with two spots on the dorsum of the mesothorax was produced in this generation, whose wings at the issue were milky pale (which is not the rule in mosquitoes), the abdominal banding being bifurcated in its lateral projections. The femora black above, cream color below, knees yellowish-white. Tibiæ black on the outer side, inner side cream color, yellowish-white banding of all the tibiæ.

The balance of this generation, which came to issue were *Culex pipiens,* with thorax scantily clothed with scales and from indistinct to no tibial banding in some specimens.

The larvæ were bred in a rain-barrel out of doors in their natural element, but under the strict precautions necessary for this work. Upward of 300 came to full growth. They were of interesting colors, most of them being of a reddish-brown with rufose heads, which before the second molt were of striking beauty with the white rings around their eyes. There were some very dark brown, and others of a light brown color. Some six specimens were of a light straw color with narrow thorax

and smaller in size than the rest. The eye in these larvæ was longer and came to a sharp point mesad and set closer to the vertex of the head. These produced adult *Culex pipiens* not any different from the others. Other variations in color, structure, susceptibility, etc., of minor importance were present in this generation. The red-brown larvæ were very delicate, the hair—which was longer than in the other varieties—and gills come out very easily when handled on a slide. They succumbed to the most trivial injury. All of the larvæ on a cold morning, November 10, were found on the shady side of the barrel. The same habit was observed in other generations of the same species on cold days. On November 14 there were about 150 larvæ in the barrel, and these were frozen solid in a half inch of ice for 36 hours. There were four issues of *C. pipiens* after this, and another freezing for several days killed the balance.

The *C. restuans* were issued before the cold weather set in, which concluded the observation on this generation. Specimens of the *C. restuans* from this generation were sent to the Department of Agriculture, through which D. W. Coquillett, of the U. S. National Museum, confirmed the identifications. This generation presented an example of the production of *Culex restuans* Theo. as a mutation from *Culex pipiens* Linn.

The next example is that of a small mass of 62 eggs in the form of an isosceles triangle; these eggs were darker at the apex than others. It was deposited October 10 and hatched in four days. This was the first generation I observed to molt three times before the pupation molt. The young larvæ before the third molt portrayed a beautiful picture with their rufose heads and white ringed eyes and dark reddish-brown antennæ and air tube; the latter tipped with a white point and clothed with but three tufts of hair, the first one of which contained fine rudimentary barbules. The general shape of the larvæ in this generation deviated somewhat from the regular form, the thorax being smaller and more of the form of *C. territans.*

A peculiar difference which was not seen in any *C. pipiens* larvæ previous, noted six days after the third molt was the specific gravity of the larvæ, which were now lighter than the water in which they were bred in a pint bowl with earthy matter at the bottom.

GH
With the Author's Compliments.

POLYGENESIS IN THE EGGS OF THE CULICIDÆ[1]

FROM THE RESEARCH LABORATORY OF
SAMUEL ELLSWORTH WEBER, VETERINARIAN.
LANCASTER, PA.

To advance such a revolutionized suggestion as is indicated by the title of this paper in the face of long established belief may be looked upon as venturesome. Although it may seem startling to the zoologist, whether I am jeopardizing my reputation or am justified in making such a broad assertion, may best be ascertained by going over the work laid down in the forthcoming papers on the facts in relation to an apparently unrecognized law in the process of evolution.

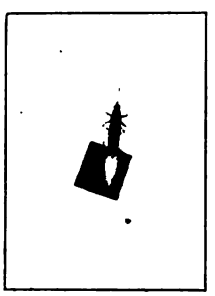

FIG. 1. *Culex pipiens* Linnæus, in the act of ovadeposition, natural size. Photographed from life by S. E. Weber.

"Polygenesis or the production of more than one species from the same egg-mass will doubtless prove a proposition difficult to bring to the minds of even the most careful scientists. Appreciating that it is contrary to ancient or modern belief as to the laws of nature, the statement is nevertheless made, and will be supported by convincing facts. The several features of importance in connection with these researches are not hasty conclusions or the result of a few years of study but even extend beyond a quarter of a century amid the pleasures, trials, and adversities in a difficult but guarded labor.

"After familiarizing myself with the strange phenomena and unraveling the question in connection with it—the question of polyembryony—in some parasitic hymenopterous insects of the family *Chalcididæ* I set about looking for other phenomena which would further explain Polygenesis or the production of different species from the same egg which was thought should be correlated with the process of budding from the same egg as I found it in Polyembryony. In this, fortune has been propitious to me.

PUBLISHER'S NOTE.—We must naturally leave the full responsibility of this alarming news to our esteemed co-worker, and remain skeptical towards it until the proof of this announcement is placed before everyone. Notwithstanding this, we did not deem it advisable to withhold it from our readers.—*Natur und Haus.*

[1] This notice, under the title, "Polygenese bei den Eiern der Stechmücken (Culicidæ)," appeared in *Natur und Haus*, Vol. XV., No. XV., May 1, 1907, pp. 236–37. It is principally extracted from an unpublished article on "Mutation in Mosquitoes."

The following phylogeny will help to convey my meaning:

POLYGENESIS	*Polyembryony.* The production of chains of individuals from one egg.	*Examples.* *CHALCIDIDÆ.*
	Mutation. The production of more than one species or *genera* from the same egg deposition.	*CULICIDÆ.* *PSOCIDÆ.*

"The second phenomenon in Polygenesis is a step which bestrides a colossal question, and in the extraordinary process is found the widest bearing upon profound biological problems."

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The type of mutation referred to in the phenomena in question, notably the reversion of life stages, of different species which had issued from one egg-mass to the progenitor which deposited the eggs, and the coming out from one and the same egg-mass of different species by a certain internal force of nature, is not the type which constitutes a mutant in the sense in which the term is used by de Vries. The latter is based on unit characters which will not fractionize with other characteristics. Such discontinuous variants or mutants may be seen to issue from egg-masses while the other method is operative.

"Since the combination of different larval species and the folding into one adult species is a fact, the unfolding must be looked for in the stream which flows from the internal state, which must be through the egg, for we have no bud-sports or shoots in animal life. (*I. e.*, not like in plants; of course we have the embryonal budding in insects as mentioned under polyembryony.) Our only course is to accept the egg-mass as the only medium through which sports—or species assuming a different character from the parent—are suddenly produced. *Hence the polygenetic power of the egg-mass in mosquitoes.*"

These phenomena are a new domain of investigation in the origin of species and may demand to be designated under other terms. They disclose what takes place in nature, and render the process of evolution amenable to direct observation.

Briefly.—Divers mosquito larvæ producing similar adults must spring from similar adults.

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December 1, 1906.

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With the Author's Compliments.

POLYGENESIS IN THE EGGS OF THE CULICIDÆ[1]

FROM THE RESEARCH LABORATORY OF
SAMUEL ELLSWORTH WEBER, VETERINARIAN.
LANCASTER, PA.

To advance such a revolutionized suggestion as is indicated by the title of this paper in the face of long established belief may be looked upon as venturesome. Although it may seem startling to the zoologist, whether I am jeopardizing my reputation or am justified in making such a broad assertion, may best be ascertained by going over the work laid down in the forthcoming papers on the facts in relation to an apparently unrecognized law in the process of evolution.

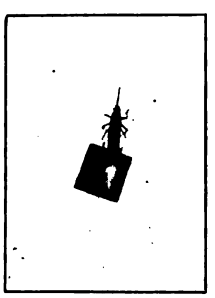

FIG. 1. *Culex pipiens* Linnæus, in the act of ovadeposition, natural size. Photographed from life by S. E. Weber.

"Polygenesis or the production of more than one species from the same egg-mass will doubtless prove a proposition difficult to bring to the minds of even the most careful scientists. Appreciating that it is contrary to ancient or modern belief as to the laws of nature, the statement is nevertheless made, and will be supported by convincing facts. The several features of importance in connection with these researches are not hasty conclusions or the result of a few years of study but even extend beyond a quarter of a century amid the pleasures, trials, and adversities in a difficult but guarded labor.

"After familiarizing myself with the strange phenomena and unraveling the question in connection with it—the question of polyembryony—in some parasitic hymenopterous insects of the family *Chalcididæ* I set about looking for other phenomena which would further explain Polygenesis or the production of different species from the same egg which was thought should be correlated with the process of budding from the same egg as I found it in Polyembryony. In this, fortune has been propitious to me.

PUBLISHER'S NOTE.—We must naturally leave the full responsibility of this alarming news to our esteemed co-worker, and remain skeptical towards it until the proof of this announcement is placed before everyone. Notwithstanding this, we did not deem it advisable to withhold it from our readers.—*Natur und Haus.*

[1] This notice, under the title, "Polygenese bei den Eiern der Stechmücken (Culicidæ)," appeared in *Natur und Haus*, Vol. XV., No. XV., May 1, 1907, pp. 236–37. It is principally extracted from an unpublished article on "Mutation in Mosquitoes."

The following phylogeny will help to convey my meaning:

POLYGENESIS
- *Polyembryony.* The production of chains of individuals from one egg. — *Examples.* *CHALCIDIDÆ.*
- *Mutation.* The production of more than one species or *genera* from the same egg deposition. — *CULICIDÆ.* *PSOCIDÆ.*

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A full grown larva was found which was different in color, size, and other structure. It pupated November 8 and issued November 13, a male, ten days before any of the others. The head and thorax were smaller than the rest of the individuals in the generation. The labial plate was of smaller dimensions with short sharp teeth and but seven on each side, as per Fig. 2 on left—upper figure—where in the others were found the regular form with nine teeth on each side, as per Fig. 2 on right side. The adult mosquito of this larva furnished a striking contrast in the development of the fourth abdominal segment. A peculiar high crescent-shaped protuberance marked this segment, around which radiated a profusion of pale yellowish setæ, Fig. 2, left. The abdominal banding very light and projected laterally without much difference in width from the dorso-median line. The part of the abdomen caudal of this large fourth segment was about one half smaller and gave the specimen an unusually odd appearance. The description otherwise did not deviate materially from *C. pipiens* and some of the variations.

Whether this is termed a hybrid or a monstrosity, it is cited to show that in a generation one or more individuals may be found which are decided aberrations from the regular form. It is upon the sudden origin of such discontinuous characteristics or differential marks, that the origin of species by mutation may be founded. By close observation such instances, as well as numerous variations of interesting description, may not infrequently be seen, and I may say, true species, not established or constant may be noted occurring as mutants in small numbers, in some chance generation.

After learning the fact that it was really possible for two or more distinct species to be produced from the same batch of eggs deposited by a certain species the female of which had been photographed and captured in the act of ovadeposition and studied in detail, it was then also considered reasonable that, as has been stated, the other end of a certain principle was the production of one species in the adult from several different species of larvæ reverting to one and the same species of adult

mosquito. And to repeat, if two species come from one, then two species could return to one.

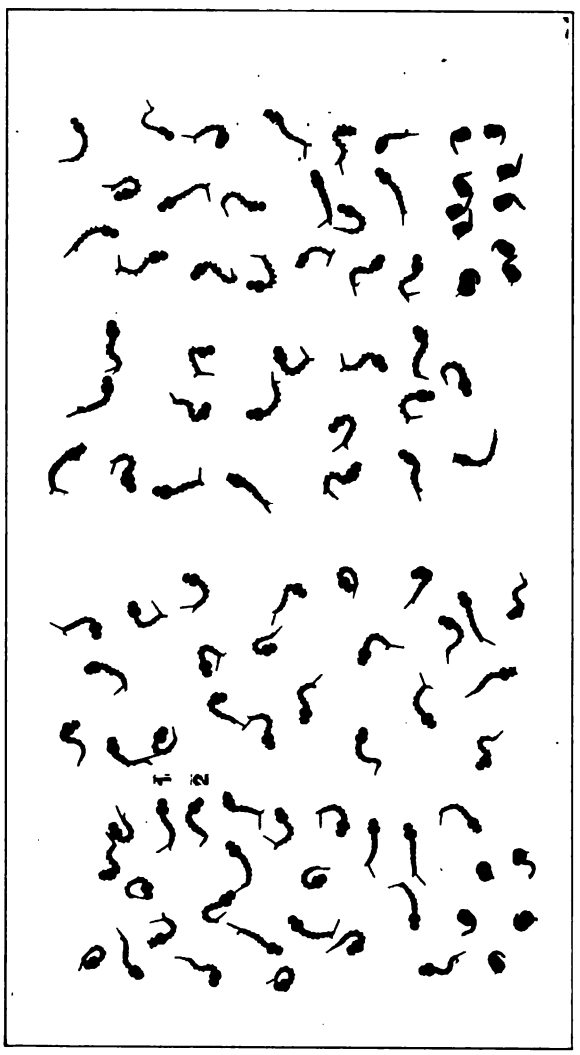

FIG. 5. *Culex salinarius* Coq. larvæ and pupæ, on left half of plate, with one exception a mutant in the generation of *Culex pipiens* Linn. at 2. The right half consists of larvæ and pupæ from a generation of *Culex pipiens*. The principal mark of contrast in the two species which may be noted with the unaided eye, is the greater width of the head between the eyes, and more flat, in *Culex salinarius* larvæ than in that of *Culex pipiens*. Note also the longer and more slender air-tube in *Culex salinarius*. Natural size. From life.

To pick up several apparently distinct larvæ, the progenitors of which were unknown was found insufficient for such a demonstration. What seemed a laborious task, now confronted this work of rounding out a most interesting principle in nature

furnished by the *Culicidæ*. After patient search, the generation to afford the much sought for knowledge which demonstrated the induction formulated by earlier observation was discovered. The next example offered gives us this remarkable explanation and is found in

CULEX SALINARIUS COQUILLETT EGGS WHICH PRODUCED CULEX PIPIENS AND CULEX RESTUANS LARVÆ AND REVERTED TO CULEX SALINARIUS ADULTS.

This was a mass of 230 eggs deposited in July. The generation was reared in a two gallon stone jar, under strict precautions, such as sterilization of jar, food and water, screening of jar, etc. Among the *Culex salinarius* larvæ was found a typically developed *Culex restuans* larva. Now comes the precious moment of placid interest in the watch of the result. The critic might easily have said, "Your larva came to the generation accidentally," as could have been the case under lack of precautions, but such argument vanishes under the truth of what happened, for at the issue the *C. restuans* larva produced a typical female adult *Culex salinarius* Coq.

There were also two larvæ of *Culex pipiens* found in this generation, which were produced from the same batch of *Culex salinarius* eggs. The question now in mind was—will they produce *C. pipiens* or will they also revert to their true progenitor? The result was one of them died and the other issued a *Culex salinarius* Coq.

We have then exemplified in the two generations of mosquitoes just noted, that two or more species may come from one progenitor by mutation, and on the other hand, that two species in a certain life-stage may result in one species in the adult stage. The reaching out of *Culex salinarius* into a part of the life stage of another species in its own genus of several individuals in a generation would at the first perception seem to be an exhibition of the principles related to Mendel's law in the life-stages of a single individual. This hereditary principle in the life-stages of insects to my knowledge has not been demon-

strated. *In these changes may be found the law which holds the secret in the process of evolution.*

Culex restuans Eggs and Larvæ, which produced Culex pipiens Adults.

A second example of transgression in life-stages is that of a mass containing 235 *Culex restuans* eggs, deposited in the latter part of June. I did not see the ovadeposition but it was evidently a *C. restuans* which deposited the eggs since they were at once noticed to be different from any others deposited before this stage of the season. It was the darkest mass in five hundred. It lay flat on the water, and the eggs were shorter and thicker and more straight than *C. pipiens* eggs. They were more obtuse at the apex and capped with a small papilla, which like the other parts of the apex were rufose in color. The hatch proved to be *Culex restuans* larvæ. The vessel containing this generation was upset and most of the larvæ lost, but the remainder, 36 in number, were all *C. restuans* larvæ. They were carefully examined—with microscope—and each one but two exceptions were typical larvæ. These two specimens had the antennæ and air-tubes of *C. restuans,* but the labial plates were not that of *C. restuans* but more like that of *C. pipiens,* one of them being armed with very sharp teeth. These specimens did not mature. Twenty-six of the remainder of the larvæ resulted in the production of adults of *C. pipiens.* Whether or not, the eggs were deposited by a *C. restuans,* or a *C. pipiens* I am unable to state.

In the next four generations I will illustrate the production of

Culex pipiens Larvæ and Adults as Mutants from Culex salinarius Eggs.

The fifth citation is a mass of 170 eggs of *C. salinarius* deposited September 12. From this batch of eggs three kinds of larvæ were produced, 70 were *C. salinarius,* ten *C. pipiens,* and one *C. restuans.* The latter was accidentally killed in handling. The two species of larvæ all unfolded adults as represented by the larvæ. The *C. salinarius* larvæ were not of the smaller variety as found in a purely typical generation. The larvæ were

larger and the air-tubes were shorter. And the adult was of larger size. The deviation from the typical *C. salinarius* was toward *C. pipiens.* From the ten *C. pipiens* larvæ eight *C. pipiens* resulted which came from the *C. salinarius* eggs. We then have an example of *Culex pipiens* Linn. as mutants from *Culex salinarius.*

CULEX SALINARIUS EGGS WHICH PRODUCED CULEX PIPIENS AND CULEX SALINARIUS LARVÆ AND ADULTS, FIG. 3.

In a small black mass of 180 *Culex salinarius* Coq. eggs deposit of September 13, two species of larvæ were found, 109 *Culex pipiens* Linn. and 42 *Culex salinarius* Coq. Here the majority were mutants, which is the opposite of the rule in mutation as I have found it in mosquitoes. The issues from October 18 to 24 were 91 *C. pipiens* mosquitoes, 45 of which were males and 46 females. See two middle transverse rows, Fig. 6. Of *C. salinarius* 17 specimens came to maturity, 8 males and 9 females. See 1st line (with exception of the specimen at right end) and 4th line, which are *Culex pipiens,* Fig. 6. It may be noticed on the plate that *C. pipiens* is larger in size but has a smaller head than *C. salinarius,* and also that it is not so dark in shade of color. In the specimen with wings spread (Fig. 6) may be seen the typical abdominal banding of *C. pipiens,* which is not present in *C. salinarius.* In the enlarged specimen with right wing extended, Fig. 3, no abdominal banding is shown. As in the larva, the head in the imago of *C. salinarius* is wider than in that of *C. pipiens.* Note also the longer wings in *C. pipiens,* etc.

The *Culex pipiens* larvæ were of two sizes and of the regular pale brown color, with a straw colored head and air-tube. In the tint stage,* the smaller were of a light pink and the larger of a faint bluish tint on the thorax with a faint trace of pink

* By the tint stage in mosquito larva I mean a certain color which appears after the larva is full grown and when approaching pupation. A scummy swelling of the thorax makes its appearance—to the unaided eye—accompanied with the most beautiful tints extending over the thorax and abdomen. This is a formation aside from the regular color of mature larvæ, and in some generations presents an interesting variety of tints, such as pink, violet, blue, green, buff, plum, etc.

on the lateral part of the abdomen. In one specimen the colored parts of the thorax—hair bases—were very dark, the air-tubes jet black, with the tinted parts of thorax and abdomen bluish, and other parts as in the pink tinted larvæ. The air-tubes were of the regular length, with one exception, in which it was found smaller, about three times as long as wide, and curved forward. Some few were found with rudimentary barbed hair in the lower tufts which clothe the air-tubes. These barbs are generally very fine and are now and then seen in the regular *C. pipiens* larvæ. The smaller larvæ of *C. pipiens* in this generation were about equal in size with the *C. salinarius* larvæ of this same generation.

The imago *C. pipiens* were of medium size and typical specimens of the species, some of them being of the form with the profusely developed scales on the dorsum of the thorax, giving the part a paneled appearance.

In the handling of these specimens the various differences in conditions attending the two species were well marked; *e. g.*, in the susceptibility to chloroform *C. salinarius* is quite different from *C. pipiens*. If a similar quantity is exhibited to both the former will revive much sooner than the latter.

Culex pipiens as Mutants from Culex salinarius.

In a generation of 155 *Culex salinarius* eggs deposited September 29 and hatched October 1, two mutants of *C. pipiens* were found. Fig. 5 represents this generation on the left half. One of the larvæ was of a light color and the other a dark. The head of the light colored larva was nearly as wide between the eyes as that of the *C. salinarius* larva and of a light straw color. Antennæ pale brown, air-tube regular proportions, two hairs in tufts, the two lower ones being longer than usual, and each hair was finely barbuled. The general color of this larva was the same as that of the *C. salinarius* larvæ in the same generation. The other mutant *C. pipiens* larva had a smaller head and was of rufose color, and was more easily distinguished among the other larvæ in the generation, the contrast in the size and color of the head being very marked. See Fig. 5, 2. The air-tube was clad with three tufts of two hairs.

FIG. 6. The two middle rows—transverse—and the single specimen at the right end in first row are *Culex pipiens* mutants from *Culex salinarius* eggs. The others in the first row, the single specimen immediately back of it, and the fourth row are all *Culex salinarius* from the same mass of *Culex salinarius* eggs. Natural size. Photographed from life under the influence of chloroform.

The fourth example of *Culex salinarius* eggs giving rise to mutants of *Culex pipiens* in larval and adult life, was a mass of 206 eggs deposited September 29 and hatched October 1. By November 14 there were 45 pupæ and 30 larvæ of *C. salinarius* and 13 *C. pipiens* larvæ, from which issued by November 29, 69 imago *C. salinarius,* 33 males and 36 females, and 9 mutants of *C. pipiens,* 2 males and 7 females.

These four last examples show that *Culex pipiens* has a tendency to be unfolded from its genus through the channels of *Culex salinarius* and are cited more particularly to show the process of mutation as it exists in nature. It is needless to say that there is perhaps no better established, or more universally common species of mosquito than *Culex pipiens* Linn. We find in the first example the latter species issuing mutants of *Culex restuans* Theobald, so that we have here a line of successive mutations from *Culex salinarius* Coq. to *Culex pipiens* Linn. to *Culex restuans* Theo. Other branches might be added to this chain, but descriptions are not within the limits of this writing.

Since the recognition but a few years ago of mosquitoes in relation to pathology, active collecting of species has been stimulated, and literature on the subject is rapidly increasing, but it is to be regretted that in certain respects it is much involved. In the course of these investigations on the life history of mosquitoes, facts have been determined which not only make plain an important process in evolution, heretofore unrecognized, but also demonstrate the vexed problem in entomology with regard to different kinds of larvæ producing similar adults. For instance, head lines fall under our eye like this*—"Diverse mosquito larva that produce similar adults" by Dr. Dyer, a review of the material in Culicid larvæ gathered by Dr. Howard, where the writers met with diverse larvæ that produced adults so similar that they were not differentiated with the material at hand.

As examples, *Culex cantans* Meigen is cited as being produced from two different larvæ, and the statement is made: "There must be two species here in spite of the apparent similarity of adults."

Culex restuans Theobald is noted as also from two forms of

* *Proc. Ent. Soc. Washington*, Vol. VI., No. 3, p. 143, 1904.

larvæ. The second form has been mentioned by Dr. Smith,* who considers it specifically distinct from *Culex restuans,* but Dyer does not consider it distinct.

Culex impiger Kirby is noted as being produced from two "abundantly distinct" larvæ.

With reference to divers larvæ producing similar adults I would further state the observation of Dr. Felt, New York State entomologist, who by personal letter states that some larvæ "are separated with great difficulty while they produce very different results, and adults resembling each other very closely may come from widely different appearing larvæ," and cites *Culicada subcantans* and *Culex abfitchii* as being produced from quite different larvæ, "while the females at least can hardly be separated beyond question, though there is a constant difference in the male genitalia." The larvæ of *Culicada impiger* and *Ades fuscus* "resemble each other somewhat closely while the adults are widely divergent."

In *Anopheles* I have noted three separate species of larvæ produce *A. punctipennis* Say. In the same species of larvæ also I have found specimens which produced *A. maculipennis* Meig. The importance of this genus in pathology demands a thorough study of the law in question relative to the mutation process as found in the species, by which a more definite knowledge of the species and their organization might be attained, which at the same time would also facilitate the complexity in the identifications by the sanitarian.

This reference, with respect to divers larvæ producing similar adults, illustrates the diversity of opinion in a seemingly perplexing subject, which as stated may be elucidated by a better understanding of the laws in connection with the mutation process of evolution. If, as stated before, we can have two or more species come from the same batch of eggs, then conversely we can have divers larva or innumerable varieties of larval species folding into one species in the imago form. To the few variations mentioned an unlimited number might be added as folding into or unfolding from a species. *These are both ends of certain changes on which hangs the law in the process of evolution,*

* *Ent. News,* XIII., p. 303, 1902.

whether species are organized into new types by the slow march of the ages or originate suddenly by "mutation." These two processes seem to be inseparable.

The innumerable variations of divers kinds and degree are to my conception of the imponderable, the very ramifications in the elementary connection which amalgamate the species in the memory of a genus, if you will allow the expression. For it seems to me as the memory of the tall oak resides in crystallized form in the acorn, so we may say the same exists in latent nature to gain expression in physical form by certain unknown intrinsic or extrinsic causes and conditions.

One of the most recent additions to the literature is "The Larvæ of Culicidæ Classified as Independent Organisms" (a reprint by Dr. Dyer and F. Knab from the *Journal of the New York Entomological Society,* Vol. XIV., No. 4, published March 14, 1906), which appeared in the *Journal of the New York Entomological Society,* Vol. XIV., p. 169, December, 1906.

Larvæ "as independent organisms" seems to sound contrary to the beautiful harmony which nature holds out everywhere. I do not mean to reflect in the least on the authors of such a title, but on the contrary, like them, regret very much the limited field "which has been assigned" to them in the study of so important a subject.

"The adults have been given into other custody, and the determinations that have been transmitted to us are, in many cases, at variance with larval characters. We have been unable to personally examine into the discrepancies without exceeding the field which has been assigned to us." This statement indicates the limits of each author's work and when brought together important parts are found in solution of continuity, which is contrary to the harmony in the history of the species and consequently such work is not as valuable as it otherwise would be. That the "specific limits are more sharply defined, or at least more readily appreciable" in the larvæ of *Culicidæ* than in the adults, should not be an argument for an institution to conduct piece-work in such a line of observation.

To return to our subject proper let me, in addition to the dialogues mentioned above, cite another by an administrative and

promoter of science which voices the sentiments of most men in the various walks of life:

"The suggestion that two distinct kinds of adults are produced from the same batch of eggs is so utterly contrary to what we believe of nature's laws that it will require the clearest possible proof for you to find any acceptance of your statements."

Whether or not I have succeeded in this, by the repeated mention above of the principle in question, can only be found by following the work herein laid down, to which the author looks forward with the pleasure of an early corroboration.

An institution executive and editor remarked: "I have been working here for thirty years and saw nothing of the kind. I don't believe it," etc. Overlooking that he was among dead specimens and books only—overlooking that the true foundation of knowledge does not lie in the great schools and other institutions, but back of them. Nay, the fundamental sources of education lie in the great stock of ideas, and individual conceptions of man's mind, and coupled with research they form the basis of all laudable progress.

This trophy or addition of an item of knowledge to the sum of scientific truth is the result of incessant toil and of no small personal sacrifice. To the facts herein stated I am not only able to make additions toward contributions to the knowledge of the species, *but to genera as well.* And, therefore, may lay a deeper and safer foundation than any yet produced in the molding of a more thorough, more direct, more plausible, more simplified, more conclusive system of thought relative to the origin of species. And I therefore trust that some one, to whom no cost would be too great, will provide means and ways of thoroughness, not only to follow, and if possible bear me out in these observations, but to expand and facilitate a piece of research. In lifting the summit level of education systematic provision for scientific research is necessary. It cannot be too urgently solicited, therefore, from the generously endowed universities and other institutions looked upon as the fountains of original research and teachers of advanced subjects to take up this most important line of work, and aid in the extension of human knowledge.

These phenomena are a new domain of investigation in the origin of species and may demand to be designated under other terms. They disclose what takes place in nature, and render the process of evolution amenable to direct observation.

The main points in these observations may be summarized:

1st. *That mutation in animal life is a fact.*

2d. That two or more species may issue from the same egg mass.

3d. That we have an exhibition of what takes place in nature.

4th. That the process of evolution is shown through unquestionable species.

5th. That I have shown a line of succession in three existing species, exemplifying the process of mutation in the origin of species.

6th. *Divers mosquito larvæ producing similar adults spring from similar adults.*

7th. That there is a certain hereditary principle of reversion exhibited in the life stages of individual species, in the *Culicidæ,* by the reversion of divers larval species to the species of the progenitor.

8th. *That we have in these phenomena of changes the process or scheme of nature by which new species are produced, by the outward process of changes from the internal state of form which can only be through the egg.*

9th. *That the egg-mass in the Culicidæ is but a part in the life cycle of the individual of a species, and is endowed with the same inherent principles as the other stages, more particularly the larval portion, and as such may be considered as A Polygenetic Factor.*

LANCASTER, Pa., November 1, 1906.